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THE INFLUENCE OF DARWIN ON THE NATURAL SCIENCES.

BY GEORGE LINCOLN GOODALE.

We are to examine the more striking features of a revolution which began half a century ago. The smoke and dust of controversy have drifted away, and it is now possible to see with some degree of clearness the magnitude of the issue and the nature of the reconstruction. In order to appreciate the completeness of the change, we must contrast, as fully as our time permits, the condition of the natural sciences fifty years ago with their state at the present time.

In 1858 Alfred Russell Wallace and Charles Darwin first gave to the public their fruitful suggestion in regard to the struggle for existence and the survival of the fittest. In the following year Darwin embodied this idea in his "Origin of Species," and illustrated it fully. Those two dates mark the beginning of a new era in natural science. By natural science, as distinguished from physical science on the one hand, and from mental and moral science on the other, is commonly meant that department of investigation which deals with living and extinct plants and animals, especially with regard to their structure and distribution. The century ending in 1859 was remarkable for its persistent attachment to a dogma in natural science which had proved more and more embarrassing as the century advanced. This dogma is known as that of the fixity, or permanence, of species.

The word species, denoting a particular kind of mineral, plant or animal, is very old in its general application, but it assumed in 1750 a definite meaning at the hands of a great reformer of natural history, Linnæus, of Sweden. He found the term used vaguely, and he gave to it a restricted signification. Everybody recognizes the fact that the living world around us is composed of individuals which resemble each other more or less closely. When these individuals resemble one another very closely indeed, just as parents and offspring are alike in almost all respects, they are held to constitute a species, varying within narrow limits, beyond which limits they never permanently trespass. This conception of species carries with it the notion that they have come down to us out of the past in straight lines of descent, or stating this in the words of Linnæus, there "are just as many species as there were forms created at the beginning." These fixed, permanent, created forms are species. As a matter of fact, in a few doubtful instances, Linnæus seems to have thought that a perplexing species might possibly have been derived from some variety of another species, but these questionable cases were so few that they cannot obscure the truth that Linnæus gave the whole weight of his authority in favor of the dogma of the permanence of species. Even in his lifetime there were bold speculators who ventured to express their skepticism regarding the validity of the dogma; but none of them made out a very good case against it, and eventually all serious opposition died away.

The influence exerted by Linnæus was largely due to his beneficent reforms in natural history, which placed the whole scientific world under obligation to him. Let us glance at these sources of his authority, by which his opinions in regard to species held almost undisputed supremacy for a full century.

Linnæus, at the beginning of his work, found a cumbersome and vexatious nomenclature. Certain sorts of plants had received names which were made up of more than twenty Latin adjectives trailing after a substantive. Linnæus cleared away this worse than useless nomenclature and replaced it by a binomial, or two-name system, which answered every purpose. Furthermore, he became so impatient at the tedious and prolix descriptions which filled many of the contemporary treatises on animals and plants, that he set himself to work to reform this fault. He constructed a sort of grammar of botany, known as philosophia botanica, in which he placed, in orderly manner, the rules which had governed him in framing his own descriptions. These rules met with general acceptance on account of their good sense, usefulness, and wide applicability. The rules insisted on brevity, clearness and accuracy. They have never been wholly superseded. Such were the two great reforms in nomenclature and in description. They placed Linnæus in the position of a master whose word was law. Besides these two reforms which were promptly and gratefully accepted, there was also a suggestion made by him in regard to the identification of plants which was so useful and attractive that it greatly increased his influence. This suggestion led a host of amateur and professional explorers to seek new plants in all countries. Your own city shared in this, as Bartram's garden proves. Some of these plants were named and described by the explorers themselves under the rules of Linnæus, but a large proportion of the remainder were placed at the disposal of the great master. This convenient system of identification partook of the nature of a system of classification, thoroughly artificial, but eminently practical. Thus by his two immense reforms and by his ingenious system of classification, Linnæus reached a point where, consciously or unconsciously, he became a dictator in many departments of natural history. It must be remembered further, that his authority was greatly augmented by the wide range of his activities, for he lived and worked before the days of specialization. Hence he could give to the world a " Systema Naturæ."

In his reforms and in his provisional system he made use of two units, the individual and the species. The individual is the unit of description, the species is the unit of classification. Both of them presented curious difficulties of definition. Thus an individual is usually defined as a thing or an organism which cannot be separated into parts without losing its identity. But if we take an individual plant, say, of rose, we can divide it into a hundred different pieces, each of which is capable of independent growth. In the higher animals, like man, for instance, and in a great many of the lower plants, complete individuality is easily recognizable; but, on the other hand, many of the lower animals and practically all of our higher plants are communities rather than individuals. If any individuality at all exists, it is composite and corporate. The other unit, the species, fares hardly better at the hands of one who tries to define it strictly. If we take the definition already quoted from Linnæus or if we define it as " a perennial succession of individuals perpetuated by generation," the determination of any given case must be largely a matter of judgment, since, as a rule, the naturalist does not and cannot have both parent and offspring to guide him in his decision. It often happens that only a single individual is at hand for description. This is especially the case in the study of collections made under difficulties, where it has been possible to get only one or two specimens of a kind. The judgment must control in such studies of resemblances. But inasmuch as we associate the idea of affinity with resemblance, the question kept arising in the minds of some naturalists even in the time of Linnæus, if resemblance is the controlling factor in determining that two or more individuals, however variant, belong to a given species, and if we claim that a given species is a line of individuals related by descent, what are we to say when we find two species very closely resembling each other? Are they related also? And by descent? It is, in short, impossible to keep the idea of relationship by consanguinity out of the mind. It forces itself at some time or other upon every student. Among those who were most embarrassed by this recurrent query which would not be silenced, was Buffon, the naturalist.

He appears to have been much troubled at different times by the perplexing question which could be explained only on the basis of transmutation, but he was not able to offer any suggestion as to the origination of species, which could be well defended. For a long time he sustained animated controversies with his contemporaries, but never to good advantage. Nor did Lamarck, another naturalist of about the same period, succeed in impressing upon his associates his views in regard to the mutability of species. He made suggestion after suggestion as to some possible method by which a change of conditions acting on the organism, could bring about a change of form and structure. He constructed a fabric of hypotheses by which he endeavored to account for the origin of species. But it is the concurrent testimony of all who have familiarized themselves with his work, that in the shape in which he urged it, it deserved a part of the ridicule with which it was ruled out of court. Geoffroy de St. Hilaire held similar views, but he could not convince his contemporaries that the suggestions were satisfactory. The poet Goethe also was intensely interested in the discussion, especially that which took place between St. Hilaire and Cuvier, and endeavored by his own writings to clear up many of these matters. But none of these were able to make any headway against the authority of Linnæus and Cuvier. Time would fail us to enumerate the nature-philosophers as they were called, and the naturalists, who rebelled with little effect against the dominance of the dogma of the fixity of species.

Their rebellion was practically of no effect, and yet today we can see that they were right in many of their contentions. Professor Osborne has given us in his excellent work, entitled "From the Greeks to Darwin," a capital sketch of these views, tracing them down from early times.

The authority of Linnæus and of Cuvier was enough to offset any of the speculations on the other side. But when the century was far advanced, the need of the readjustment of views became increasingly evident. On the one hand was the obvious fact that species do not change enough from year to year, to account for derivative descent, but, on the other, there were many questions which could be answered only by frankly admitting such derivation. First of all, it was exceedingly difficult to meet the problems presented by fossil plants and animals. To face these problems, even in a half-hearted way, it was necessary to assume the occurrence of successive catastrophes and fresh creations. And when, especially by the work of Lyell, the geologist, it became plainer, day by day, that instead of sudden scene-shifting in the drama of animal and plant-life, the play had always gone with no interruption, the situation became almost desperate. Secondly, the existence of rudimentary organs could not be at all understood on the basis of fixity of species. Useless organs have no place whatever in that scheme of primary creation. Thirdly, there were hosts of questions arising in regard to distribution of plants and animals which no man could answer on the basis of constancy of species.

Meanwhile, collections were increasing, and problems were becoming more insistent. And so the century closed in 1858, with many dissatisfied naturalists throughout the world, who were still in the dark and without a guiding clue. There was not in any country any scientific explanation of these great questions which commanded confidence or even respect. The dogma of constancy of species bound fast with its fetters all natural science and hindered further progress. It was at this time that Mr. Wallace and Mr. Darwin made their happy suggestion. The two communications were presented to the Linnean Society, on July 1, 1858, practically as a joint production. All the inflammable materials were at hand for a disgraceful contention as to priority between two path-breaking pioneers. Each one was confident that he had found a plan by which it was possible to cut one's way through a formidable tangle of phenomena. But these great souls, Darwin and Wallace, joint authors of the hypothesis, vied with each other to give the other full credit for independent discovery. And more than this, they searched for those who had thought out their thoughts before them, and were rejoiced when they found that at least one thinker had anticipated them both, and that very many thinkers had been near the discovery. This noble example of magnanimity must be placed among the factors which have created Darwin's immense influence.

The suggestion or hypothesis is chiefly a statement of admitted facts. Both of these naturalists had been overwhelmed by the luxuriance of life in the tropics and both had been readers of a treatise in which the relations of numbers of living beings to space and food had been intelligently treated. Surrounded by tropical plants, and investigating tropical animals, they independently applied the treatise they had been perusing to the conditions around them. Wallace and Darwin observed what everybody knows, that in countless cases, the offspring largely outnumber the parents, and that this necessarily brings about a struggle for space and food. They also were much impressed by the wide variability of species, some varieties turning slightly away from the parental type in one direction, and others in other directions. And thirdly they saw what every one sees, that the conditions surrounding the organism are undergoing changes in respect to light, heat, moisture and the presence of other organisms. And next, these two naturalists did what no one else (save one) had ever done, namely, they put these three factors together, and framed a suggestive hypothesis. The hypothesis merely places a suggestion under all the foregoing facts, and it is this—admitting, as everyone must, that there are more plants to be grown and more mouths to be fed than there is room or food for, is it not likely that the fittest among the varieties will, on the whole, stand the best chance? Not necessarily the strongest, but those best fitted for the conditioning surroundings will survive. And then came a startling inquiry from both of them; may not all this perhaps account for much that we know about the structure and distribution of organisms and the groups of organisms which we call species? This is a very innocent question and the papers did not excite much attention at the time; in fact Mr. Darwin says that the only remark he could recall was by a naturalist who thought that all "that was new in them was false, and what was true was old."

A year later the same suggestion, amplified in many particulars and copiously illustrated was published in the famous work entitled the "Origin of Species," and then an alarm was sounded all along the line.

We pass now to a short study of the immediate effect of the publication of the "Origin of Species." Let us not waste any time in recalling the bitter strife which the alarm-signal began. Let bygones be bygones. Those who were most prominent in antagonizing the hypothesis are most anxious now to have their hostile attitude forgotten. In the first place, we may say in a general way that the hypothesis met every problem fairly and squarely. It explained the succession of life on our planet, and pointed out a solution of the most puzzling problems of distribution. There were a few questions in regard to fossils which seemed to demand that the hypothesis should be strengthened by one of the tentative hypotheses suggested by Lamarck, which had fallen into soil sterile in his time, but now receptive and fertile. It explained the mysteries of parasitism, and of vanishing and rudimentary organs. It opened up new fields of research in all directions, and gave a fresh interest to all the old parts of the science. It showed that resemblances meant relationship, that is, affinity by birth, and that it was no longer necessary to apologize shamefacedly for saying that two plants or two animals were related. Under the new light it could be seen that the species were no longer to be regarded as dry things to be placed on shelves and catalogued, but as histories to be wrought out. To be sure, this is not always easy to do, and there are differences of opinion as to the affinities in certain cases. It is of course a matter of discriminating judgment.

The "Origin of Species" invaded at once new fields of research and stimulated investigation in all the territory around the domain of natural science; it has proposed new problems but it has held out the key to solve them. We should be untrue admirers of Darwin if we should forget that he regarded his suggestion as not universally applicable. At least in some parts of the subject of palæontology, as we have already remarked, one of the suggestions made by his predecessor Lamarck appears to be more satisfactory, because it brings out clearly two points of importance, response to surroundings and inheritance of acquired characters. From lack of time Darwin was unable always to measure precisely the exact degree of variation in the cases before him, but he often used rough and ready methods. Let us realize, however, that from these crude methods has sprung up a new science, biometry, which is engaged in investigating and measuring the most minute variations. It is characterized by the extreme of exactness.

When we look over the constantly lengthening list of works inspired by Darwin's genius, and gathered together under the heading Darwinian bibliography, we can appreciate the greatness of the service rendered by him in freeing science from the shackles of the dogma of constancy of species. In order to render this voluminous Darwinian literature readily available, it is divided into many separate groups, such as relations of flowers to insects, climbing plants and so on, and each of these groups is divided again, and many of them lead down or up to practical applications. Perhaps the most enticing of all the new fields thrown open to investigation by discarding the dogma, is that of purposeful breeding of plants and animals. In this great domain of research there are many workers, a few of whom, it is not ungracious to call somewhat ungrateful. Some of these ungrateful students indulge now and then in unfriendly criticism of particular views as to heredity assumed to have been held by Darwin. Such critics forget that if it were not for the help given by Darwin's search-light they would now be groping in darkness. Breeding to points, as it is called, deals with varieties under cultivation and domestication.

It must be unequivocally stated that from the time of Linnaeus down, variation and varieties have been recognized within the limits of species, but they had usually been regarded as so unimportant that they were practically ignored. They were considered by Linnæus playthings and profit-makers for horticulturists and nothing more.

The students of plant-breeding and animal-breeding in studying variation have rightly introduced some modifications of the original idea suggested by Darwin, and hence we have all sorts of new names for the different phases, such as Mendelism, Neo-Lamarckism, Neo-Darwinism, Weissmannism and the like. Verily, it does seem as if the strength of an article of faith is known by the schisms it keeps.

Two especially good results have come about scientifically from these studies of minute variations in biometry and eugenics. The first is that many varieties are now recognized as species in the making. Secondly, some of our acknowledged species are probably groups of species. Perhaps this admission may lead to too great a splitting up of established species. For instance, the species of American hawthorn, formerly counted by a couple of scores at most, are now counted by hundreds. But if the new so-called species are merely races, that is, established varieties, they are at least nascent species, and ought to have a place in the rcords. And further, it is no longer a misdemeanor in science to break up a species into its form-elements.

And now, in bringing this sketch to a close, let us confess frankly that the cause of variation, on which natural selection depends, is not yet positively known. That is the most important and inviting subject in biological science today.

Besides the liberating influences of Darwin's work on species, and its stimulating effect on all departments of biological inquiry, there is still to be noted the influence of Darwin's personal example of frankness, patience and magnanimity. It is good to remember that he would never indulge in controversy regarding his views relative to species. To be sure he had most valiant champions, who rather enjoyed a free fight, but he did not himself waste his time in discussion. He preferred to employ all of his scanty minutes saved from the exactions of physical infirmity, for the nobler pursuit of Socratic questioning. Sometimes he asked questions of men, he was always asking questions of nature. Such an example of insatiable thirst for truth carries with it a profound influence for good, not only in science but in all departments of thought and in every-day affairs. Darwin's influence has been emphatically stimulating and wholesome. But, for a moment, let us ask what if his hypothesis which explains so much, but which from the nature of the case is unprovable, should hereafter be replaced by some new hypothesis on the whole more satisfactory? Of this at least we are positive: what has been done in this revolution cannot be undone; we never can go back to the dogma of the constancy of species.

It is worth while to reflect a moment upon an historical parallel which has been often cited and which will always stand as an object of comparison, namely, the discovery by Copernicus. Can we imagine what our sensations would have been on the morning when it was first seriously announced that the sun does not really rise, but merely appears to do so because the revolving earth turns toward it? It is difficult for us to realize the immensity of the shock of being thus commanded to change our views as to the entire order of the solar system. We should probably have resisted surrender as long as possible.

But, after a while, when it became clear that the hypothesis of Copernicus explained most of the phenomena of the heavens satisfactorily, we should have adjusted ourselves to the new conception, although we should have retained some of our former expressions in common speech, "the sun rises" and "the sun sets."

Here and there diligent search may find some person who holds that the accepted view as to the solar system is wholly wrong, and who maintains with the ancients that the sun *does* move and that the earth is flat.

But probably there is not today a single competent naturalist who looks upon species as permanent or fixed. That dogma disappeared when the Darwinian hypothesis compelled the scientific world to reëxamine the subject in the light of variation. That revolution in natural science has been complete.